CLAIMS

1. A high-strength hot-rolled steel sheet excellent in shape fixability, wherein ferrite or bainite is the maximum phase in terms of percent volume,

satisfying all of the following at least at 1/2 of the sheet thickness:

(1) a mean value of X-ray random intensity ratios of a group of {100}<011> to {223}<110> orientations is 2.5 or more,

(2) a mean value of X-ray random intensity ratio of three orientations of {554}<225>, {111}<112>, {111}<110> is 3.5 or less,

(3) X-ray random intensity ratio of {100}<011> is larger than that of {211}<011>,

(4) X-ray random intensity ratio of {100}<011> is 2.5 or more,

having at least one of an r-value in a rolling direction and the r-value in a direction perpendicular to the rolling direction is 0.7 or less,

having anisotropy of uniform elongation ΔuEl is 4% or less,

having an anisotropy of local elongation ΔLEl is 2% or more, and

having an ΔuEl which is ΔLEl or less,

where:

$\Delta uEl=\{|uEl(L)-uEl(45°)|+|uEl(C)-uEl(45°)|\}/2$

$\Delta LEl=\{|LEl(L)-LEl(45°)|+|LEl(C)-LEl(45°)|\}/2$

uEl(L): Uniform elongation in a rolling direction
uEl(C): Uniform elongation in a transverse direction
uEl(45°): Uniform elongation in a 45° direction
LEl(L): Local elongation in a rolling direction
LEl(C): Local elongation in a transverse direction
LEl(45°): Local elongation in a 45° direction.

2. A high-strength hot-rolled steel sheet excellent in shape fixability according to claim 1,

characterized in that an occupancy rate of iron carbide, diameter of which is 0.2 μm or more, is 0.3% or less.

3. A high-strength hot-rolled steel sheet excellent in shape fixability according to claim 1, characterized in that an aging index AI is 8 MPa or more.

4. A high-strength hot-rolled steel sheet excellent in shape fixability according to claim 1, characterized by containing, in terms of weight %,

C: 0.01 to 0.2%,
Si: 0.001 to 2.5%,
Mn: 0.01 to 2.5%,
P: 0.2% or less,
S: 0.03% or less,
Al: 0.01 to 2%,
N: 0.01% or less, and
O: 0.01% or less

and remainder Fe and unavoidable impurities.

5. A high-strength hot-rolled steel sheet excellent in shape fixability according to claim 4, characterized by further containing at least one or more element selected from Nb, Ti and V with a total of 0.001 to 0.8%, in terms of weight %.

6. A high-strength hot-rolled steel sheet excellent in shape fixability according to claim 4 or 5, characterized by further containing at least one or more, in terms of weight %,

B: 0.01% or less,
Mo: 1% or less,
Cr: 1% or less,
Cu: 2% or less,
Ni: 1% or less,
Sn: 0.2% or less,
Co: 2% or less,
Ca: 0.0005 to 0.005%,
Rem: 0.001 to 0.05%,
Mg: 0.0001 to 0.05%,
Ta: 0.0001 to 0.05%.

7. A high-strength hot-rolled steel sheet excellent in shape fixability according to claim 1, characterized by containing, in terms of weight %,

C: 0.02 to 0.3%,

at least one or more element selected from the following group consisting of, total 0.1 to 3.5%, in terms of weight %,

Mn: 0.05 to 3%,
NI: 3% or less,
Cr: 3% or less,
Cu: 3% or less,
Mo: 1% or less,
Co: 3% or less and
Sn: 0.2% or less,

at least one or both consisting of, total 0.02 to 3% in terms of weight %,

Si: 3% or less and
Al: 3% or less

and remainder Fe and unavoidable impurities, and having multi-phase structure, wherein ferrite or bainite is the maximum phase in terms of percent volume, and a percent volume of martensite is 1 to 25%.

8. A high-strength hot-rolled steel sheet excellent in shape fixability according to claim 7, characterized by containing, in terms of weight %, at least one or more element selected from Nb, Ti and V with a total of 0.001 to 0.8%, in terms of weight %.

9. A high-strength hot-rolled steel sheet excellent in shape fixability according to claim 7 or 8, characterized by further containing at the least of one or more element selected from the following group consisting of, in terms of weight %,

P: 0.2% or less,
B: 0.01% or less,
Ca: 0.0005 to 0.005% and
Rem: 0.001 to 0.02%

10. A high-strength hot-rolled steel sheet

excellent in shape fixability according to claim 4 or 5, wherein the steel sheet is plated.

11. A high-strength hot-rolled steel sheet excellent in shape fixability according to claim 7 or 8, wherein the steel sheet is plated.

12. A method of producing a high-strength hot-rolled steel sheet excellent in shape fixability comprising the following steps,

hot-rolling a cast slab having a composition according to claim 4 or 5 as cast or cooled once, then reheated to a temperature range of 1000-1300°C, with a total reduction ratio of 25% or more at Ar_3 to (Ar_3+150)°C, temperature at finishing hot-rolling start, TFS, and temperature at finishing hot-rolling end, TFE, simultaneously satisfies following Equations (1) to (4), and

cooling hot-rolled steel sheet, then

coiling at below critical temperature T_0 determined by the chemical composition of the steel sheet shown in the following Equation (5) and a temperature of 400 to 700°C,

$$TFE \geq Ar_3 \quad (1)$$

$$TFE \geq 800°C \quad (1')$$

$$TFS \leq 1100°C \quad (2)$$

$$20°C \leq TFS-TFE \leq 120°C \quad (4)$$

$$T_0=-650.4\times\{C\%/(1.82\times C\%-0.001)\}+B \quad (5)$$

where B is found from the composition of the steel expressed by weight %

$$B=-50.6\times Mneq+894.3$$

$$Mneq=Mn\%+0.24\times Ni\%+0.13\times Si\%+0.38\times Mo\%+0.55\times Cr\% +0.16\times Cu\%-0.50\times Al\%-0.45\times Co\%+0.90\times V\%$$

$$Ar_3=901-325\times C\%+33\times Si\%+287\times P\%+40\times Al\% -92\times(Mn\%+Mo\%+Cu\%) -46\times(Cr\%+Ni\%)$$

13. A method of producing a high-strength hot-rolled steel sheet excellent in shape fixability according to claim 12, characterized by further controlling a friction coefficient to not more than 0.2 in at least one pass in the hot-rolling in a temperature range of Ar_3 to (Ar_3+150)°C.

14. A method of producing a high-strength hot-rolled steel sheet excellent in shape fixability characterized by applying skin pass rolling of 0.1 to 5% to hot-rolled steel sheet produced by the method of producing a high-strength hot-rolled steel sheet excellent in shape fixability according to claim 12.

15. A method of producing a high-strength hot-rolled steel sheet excellent in shape fixability comprising the following steps,

hot-rolling a cast slab having a composition according to claim 7 or 8 as cast or cooled once, then reheated to a range of 1000 to 1300°C, with a total reduction ratios of 25% or more at Ar_3 to (Ar_3+150)°C, temperature at finishing hot-rolling start, TFS, and temperature at finishing hot-rolling end, TFE, and calculated residual strain $\Delta\varepsilon$ to simultaneously satisfy following relations (1) to (4), and

cooling hot-rolled steel sheet, then

coiling at below critical temperature T_0 determined by the chemical composition of the steel shown in the following relation (5) and a temperature of not more than 400°C:

$$TFE \geq Ar_3 (°C) \quad (1)$$

$$TFS \leq 1100°C \quad (2)$$

$$\Delta\varepsilon \geq (TFS-TFE)/375 \quad (3)$$

$$20°C \leq (TFS-TFE) \leq 120°C \quad (4)$$

$$T_0 = -650.4 \times \{C\%/(1.82 \times C\% - 0.001)\} + B \quad (5)$$

where, B is found from the composition of the steel expressed by weight%,

$B=-50.6\times Mneq+894.3$

$Mneq=Mn\%+0.24\times Ni\%+0.13\times Si\%+0.38\times Mo\%+0.55\times Cr\%$
$+0.16\times Cu\%-0.50\times Al\%-0.45\times Co\%+0.90\times V\%$

where,

$Ar_3=901-325\times C\%+33\times Si\%+287\times P\%+40\times Al\%-92$
$\times(Mn\%+Mo\%+Cu\%)-46\times(Cr\%+Ni\%)$

$\Delta\varepsilon$ is found from the equivalent strain εi (i is 1 to n) given at each stand of the n stages of finishing rolling for the rolling, time ti (sec) (i=1 to n-1) between stands, time tn (sec) from the final stand to the start of cooling, rolling temperature Ti(K) (i=1 to n) at each stand, and a constant R=1.987.

$\varepsilon=\Delta\varepsilon 1+\Delta\varepsilon 2+\cdot\cdot+\Delta\varepsilon n$

where, $\Delta\varepsilon i=\varepsilon i \times \exp\{-(ti^*/\tau n)^{2/3}\}$

$\tau n=8.46\times 10^{-9} \times \exp\{43800/R/Ti\}$

$ti^*=\tau n \times (ti/\tau i+t(i+1)/\tau(i+1)+\cdot\cdot\cdot+tn/\tau n\}$

16. A method of producing a high-strength hot-rolled steel sheet excellent in shape fixability according to claim 15, characterized by further controlling a friction coefficient to not more than 0.2 in at least one pass in the hot-rolling in a temperature range of Ar_3 to (Ar_3+150)°C.

17. A method of producing a high-strength hot-rolled steel sheet excellent in shape fixability characterized by applying skin pass rolling of 0.1 to 5% to hot-rolled steel sheet produced by the method of producing a high-strength hot-rolled steel sheet excellent in shape fixability according to claim 15.